A QUARTER CENTURY OF NUCLEAR WASTE MANAGEMENT IN JAPAN

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First of all, I would like to express my sincere appreciation for providing me an opportunity to talk at the WM Conference. I particularly appreciate Prof. Morton Wacks for inviting me as a Plenary Speaker. The WM conference is now a large annual event not only for US experts of nuclear waste management but also for the worldwide nuclear community. I am very much pleased and honored to give a talk at such an important setting.

My talk is entitled "A QUARTER CENTURY OF NUCLEAR WASTE MANAGEMENT IN JAPAN". Since the first statement on the strategy for radioactive waste management in Japan was made by the Atomic Energy Commission (AEC) in 1976, a quarter century has passed, in which much experience has been accumulated both in technical and social domains. I will look back in this 25-year history of radioactive waste management in Japan by highlighting activities related to high-level radioactive waste (HLW) disposal.

The management of waste is increasingly recognized as a major challenge in modern society and great efforts are being made towards minimizing waste production or recycling waste materials into useful products. Nevertheless, considerable quantities of waste are produced which have no obvious further use or are too costly to recycle and which must therefore be disposed of. The disposal of wastes can have a negative impact on the environment and hence must be carefully planned. The precautions taken for the disposal of radioactive waste are especially stringent and sophisticated repositories have been designed to ensure that these wastes are isolated safely from the environment for as long as they remain hazardous.

Radioactive wastes arise from the operation of nuclear power plants, fuel cycle facilities and from the diverse use of radionuclides in medicine, industry and research. The main source of radioactive waste in Japan is nuclear power production. The first commercial nuclear power plant started operation in 1966. Since then, the use of nuclear energy in Japan has expanded steadily. As of the end of the year 2000, 53 nuclear power reactors are in operation and their capacity makes up 45 GWe. Nuclear energy in the year 2000 was 34% of the total electricity production in Japan and the total amount of electricity generation since 1966 has reached 300 TWh. As of the end of 2000, spent nuclear fuel corresponding to approximately 14,400 vitrified HLW canisters had been produced (including fuel currently in reactors). The total inventory to be disposed of is estimated to correspond to 40,000 canisters of vitrified HLW by the year 2020.

Japan's basic policy on nuclear energy is based on the AEC document, "Long-Term Program for Research, Development and Utilization of Nuclear Energy" (referred to as the Long-Term Program), which is reviewed and revised every five years. Accordingly, spent nuclear fuel discharged from the nuclear reactor will be reprocessed to recover usable uranium and plutonium with the resulting highly radioactive wastes being solidified for subsequent disposal.

Radioactive wastes arising from the nuclear fuel cycle are now classified according to their content of alpha and beta/gamma radionuclides. These are:

- high-level radioactive waste (HLW): wastes separated from spent nuclear fuel during reprocessing
- uranium production wastes: wastes arising upstream of nuclear fuel cycle

- NPP wastes: wastes that result from operation and decommissioning of nuclear power plants
- TRU wastes: wastes containing transuranic elements arising from operation and decommissioning of reprocessing plants and MOX fuel fabrication facilities
- miscellaneous wastes: wastes arising from medicine, industry, research and decommissioning of research and test reactors including nuclear laboratories

The management strategy differs for each category. NPP waste with relatively low activity level is being disposed of at the Rokkasho site by JNFL. TRU waste and uranium production waste are in storage and a basic strategy is still in discussion by the AEC. The Nuclear Safety Commission (NSC) is responsible to provide guidelines for establishment of relevant safety regulations for disposal of these wastes.

With respect to HLW, as specified in AEC's 1976 statement, geological disposal has been targeted as the most promising option. The AEC stated the technical feasibility of geological disposal should be investigated first. Since then, the Power Reactor and Nuclear Fuel Development Corporation (PNC, now JNC) and other organizations such as the Japan Atomic Energy Research Institute (JAERI) and the Geological Survey of Japan (GSJ) have conducted R&D programs according to this policy. In the course of the R&D activities, the AEC's Advisory Committee on Radioactive Waste Management (ACRWM) in its 1980 report endorsed the concept of disposal based on a multibarrier system, thus providing the basis for geological disposal in Japan. The ACRWM also stated that investigations should be carried out for a wide range of geological environments, without specifying any particular type of rock. Taking into account the discussions at ACRWM, the basic concept for HLW disposal were summarized more concretely in AEC's 1987 "Long-Term Program." The Long-Term Program specifies that high-level radioactive waste in a solidified or vitrified stable form be stored for 30 to 50 years to allow cooling and then disposed of in a repository based on a multibarrier system in stable geology at a depths greater than several hundred meters below ground surface.

An important step occurred when ACRWM indicated, in its 1987 guidelines, the need for integration of R&D results to discuss the feasibility in generic terms for HLW disposal in Japan, which in turn promotes understanding of geological disposal in both the scientific community and the general public. Following this, PNC published a comprehensive first progress report on R&D in 1992. The report is known as H3 and supports the following major points:

- A sufficiently stable deep geological environment to ensure the performance of the multi-barrier system can be found in Japan, even though the country is located in a tectonically active zone;
- The repository can appropriately be designed and constructed based on presently available engineering technologies;
- Long-term safety can be ensured, based on the performance of the multi-barrier system, with particular emphasis on near-field performance provided by a massive engineered barrier system, taking into account the complex geology expected in Japan.

It is broadly acknowledged, even in the general public, that the active tectonic setting and complexity of geology are the most critical issues for the technical feasibility of geological disposal in Japan. The results of H3 were therefore carefully reviewed by the AEC to identify the future direction of the HLW disposal program. The review confirmed that the "near-field approach" with a massive EBS, developed as a Japan-specific approach, is appropriate in order to making the safety case. It was however also pointed out that this report lacked sufficient information on geological environment and thus the AEC concluded that further generic R&D activities were needed to increase confidence in the technical basis for disposal and thereby increase flexibility in future siting.

Following H3, the Japan Nuclear Cycle Development Institute (JNC, successor of PNC) pursued R&D to provide more reliable data on geological conditions at two study sites, and completed the second progress report (referred to as H12). H12, also a generic feasibility study, was submitted to the AEC in November 1999. The primary objective of H12 as specified in the AEC 1997 Guidelines (provided by the AEC's Advisory Committee on Nuclear Fuel Cycle Backend Policy (ACNFC); "Guidelines on Research and Development Relating to Disposal of High-Level Radioactive Waste in Japan") is to demonstrate more rigorously and transparently the technical feasibility and reliability of the specified disposal concept and to provide input for future siting and regulatory processes. Different from H3, the process of H12 integration was step-wise and opened to the public to ensure its transparency and to elicit opinions from a wider audience. Extensive peer review was also carried out for the draft report by foreign experts and an NEA International Review Group.

After receiving H12, the AEC performed an independent review and concluded that the technical basis integrated in H12 satisfies the technical requirements prescribed in the 1997 AEC Guidelines. In H12, the long-term safety of a repository system is evaluated by a rigorous performance assessment method that includes a comprehensive evaluation of the uncertainties involved. Despite remaining uncertainties at the generic stage of the R&D program, it was demonstrated that a geological repository would lead to negligible dose rates calculated to be sufficiently lower than the safety guidelines established in other countries and by international organizations.

As a result, the largest part of the past 25-years of the Japanese HLW disposal program was spent for generic R&D studies without discussion of siting and institutional frameworks. We can conclude that this approach was motivated by the need to consider the geological features specific to Japan and the need for answering key technical questions relevant to these features. We can, however, also recognize the important role of generic R&D in the early stages of the repository program, which provides a foundation for subsequent phases of the program.

In parallel with R&D activities for H12, the Special Committee on High-Level Radioactive Waste Disposal, established by the AEC, started to conduct a review focused on the social and economic aspects of HLW disposal, a key aim being to improve social recognition of the project. In 1998, the Special Committee made recommendations in its report regarding disclosure of information, securing of funds, the concept for establishing the implementing organization, and the development of a reliable and transparent system for the selection of a potential disposal site. It was noted in the report that H12 should provide a technical basis for promoting the understanding of the general public and that research and development should be conducted in an open and transparent manner.

At the direction of the Special Committee, the Government has been applying a system to call for public comments in the process of drafting policy documents. For example the 1997 AEC Guidelines, the H12 review report, the revised Long-term Program, were all subject to this external review. In order to promote dialogue with the public, the Science and Technology Agency (now the Ministry of Education, Culture, Sports, Science and Technology) organized a "Radioactive Waste Symposium" 23 times at major cities around Japan, during a period of two years from December 1998 to December 2000. JNC, on the other hand, held a forum on HLW disposal four times in the same period and provided space on their web-site to facilitate public comments. Also, JNC has been active in providing information services on H12. The report was distributed to all public libraries (2,750 libraries) in Japan. Moreover, the H12 Internet Library was developed and opened to the public to access background information supporting the H12 report in a structured manner to assure transparency.

In the year 2000, the geological disposal program in Japan moved from the phase of generic R&D into the phase of implementation. Following the technical achievements in H12 and activities for public understanding, legislation titled the "Specified Radioactive Waste Final Disposal Act" was created in June

2000 and thereby established the Nuclear Waste Management Organization of Japan (NUMO) in October 2000. NUMO is the implementing organization responsible to pursue the overall HLW disposal program in Japan.

The Act specifies the overall framework for implementation and defines the roles and responsibilities of the Government (i.e. METI: Ministry of Economy, Trade and Industry) and relevant organizations including NUMO, the funding management organization (i.e. RWMC: Radioactive Waste Management Funding and Research Center) and the owners of power reactors. Under the Act, METI is responsible for establishing the basic policy and final disposal plan for a 10-year term and renewing the plan every 5 years. The assigned activities of NUMO include selection of the repository site, developing licensing applications, construction, operation and closure of the repository as well as collection of fund. According to the present schedule, repository operation will start as early as the 2030s.

As producers of HLW, the owners of the nuclear power plants are responsible for bearing the costs for the repository development program. They are required to make contributions to a disposal fund in accordance with the amounts of electricity generated. NUMO commits to RWMC the management of the collected fund. The budget for NUMO's program is allocated from the fund and authorized by METI. Management of the fund by RWMC is also supervised by METI. The total cost of disposal is currently estimated at approximately 3 trillion yen for a repository with 40,000 canisters of vitrified HLW. This corresponds to 0.13 yen/kWh or $23 billion dollars under current exchange rates.

The Act states the regulation relevant to safety of final disposal shall be developed separately. The Advisory Committee on Radioactive Waste Safety Regulations of the NSC deliberated on safety regulations for the geological disposal system based on input from the H12 report. Their first report on the basis for safety standards for HLW disposal was published in November 2000, taking account of public comments. The report mainly specifies safety fundamentals, guidelines for site selection, basic considerations for safety assessment and management of the disposal site. The newly established Advisory Board on HLW Repository Safety succeeds the roles of this Advisory Group and has been carrying on discussions on safety relevant issues.

In the siting process, it is especially important to promote public understanding of geological disposal and to obtain their trust. It should be noticed from this point of view that site selection will proceed in a stepwise and transparent manner as clearly defined in the Act. In order to ensure this, NUMO is taking a variety of measures to enhance confidence in its activities, for example, the publication of documents, a web-site, etc., and provides opportunities for concerned people to voice their opinion.

As the first milestone for the siting process, NUMO announced to the public an overall procedure for selection of preliminary investigation areas for potential candidate sites on October 29, 2001. The specific feature of the procedure is that preliminary investigation areas for a candidate disposal site will be selected on a voluntary basis. This is aimed at ensuring transparency and promoting public involvement in the decision-making process. Furthermore, the Government will provide financial support to encourage such volunteers.

We can summarize lessons learned from a quarter century of Japanese nuclear waste management, as embodied in the progress of the HLW disposal program as follows:

- Stakeholder confidence is the basis for public trust, dialogue is desirable to identify stakeholder concerns and to increase public trust in the disposal concept in accordance with the site selection process;
- A robust safety concept, based on a combination of an appropriate geological environment, an effective engineered system and a reliable safety assessment is essential, but may not always be

enough, by itself, to justify stakeholder confidence;

- An independent, technically competent regulator, working as a bridge between stakeholders and the repository implementing organization, may help to gain increased public trust in a fair, equitable and safe process.

Taking into account these lessons, it is recognized that the following aspects are of prime importance as we move forward:

- A stepwise approach as a basis for siting and repository development;
- Ensuring traceability and transparency of the information for decision making;
- Evaluating options such as retrievability and extended institutional control;
- Demonstration of repository technology.

Japan has been active in promoting international cooperation in connection with its R&D program. The output from the collaboration has been extremely valuable in improving our repository program by identifying areas of strength and weakness and thereby in generally ensuring a sound technical basis. This will be the case in confidence building for implementation of HLW geological disposal because the repository development program will continue over a long time period. Recognizing that success in one country's program would lend support to the programs in other countries, we will further promote international collaboration in our program, sharing experiences with other programs toward our common final goal. I believe such an international collaboration framework should be the most important legacy for the next quarter century.

Thank you for your attention.